

Comparative Climatology of Four Marine Stratocumulus Regimes

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1. Introduction

Much has been made of clouds in the climate system of late, including a Symposium on the Role of Clouds and Chemistry in Global Climate at the 1989 Annual Meeting of the AMS and a special session on Clouds and Climate at the Spring, 1989, AGU Meeting. On top of this high visibility in the *scientific* community, there seems to be the *popular* perception that, as climate warms, clouds will tend to occur more often—i.e., their time/space areal coverage will increase—thus helping to ameliorate the problem of global warming. Of course, the FSET community is unlikely to take such a stand, for at least two reasons. First, it is overly simplified: if *cirrus* cloud coverage increases, the problem of global warming is likely to be exacerbated. Second, the relationship of cloud coverage to average temperature is not at all obvious. One of the reasons to continue FIRE toward Phase II is to attempt to develop a quantitative understanding of just this question.

As currently envisioned, the second set of FIRE IFO's will again be process-oriented, using a coordinated observational approach to examine the behavior of cloud systems on the time and space scales of the individual cloud elements composing the systems. A complementary approach, embodied by the large-scale, long-term FIRE components, is the analysis of existing climate data sets

without specific concern about the behavior of the individual cloud elements. One such study is the topic of this paper. The focus here is on the climatology of MSc cloud regimes off the west coasts of California, Peru, Morocco, and Angola. The material presented here complements the brief climatology of July that appears in the "Grey Book", the FIRE Phase II Research Plan (FIRE Project Office, 1989)¹. This abstract, due to space limitations, presents the long-term, annual averages of several quantities of interest in the four MSc regimes.

The climatologies presented here were constructed using the Comprehensive Ocean-Atmosphere Data Set—COADS (Woodruff et al., 1987). A 40-year time series of the observations (1948-1987) was extracted for 32°x32° analysis domains in the four MSc regimes; the figures to follow are simply averages of these data sets. The data were taken from the monthly-averaged, 2° product, and the resolution of the analysis is therefore limited to scales of greater than about 200 km with sub-monthly variability not resolved. Background maps for the four areas of interest are shown in Fig. 1, with 2° squares superimposed. In contrast to actual coastlines, the COADS land squares

¹ The July SST and cloud cover figure captions in the Grey Book were inadvertently transposed.

(dark in Fig. 1) provide only a crude estimate of geography. Consequently, contours near the coast are not necessarily accurate; this point is underscored by the contamination of coastal squares by observations made near shore. In addition, the plotting package shifts data to the centers of the 2° squares; therefore the coastal observations do not represent open ocean conditions well. The figures to follow therefore take the expedient approach of blanking out the near-shore COADS data. In addition, the observations in the southwest corner of the domain off Peru are sparse (the hatched squares were omitted from the analysis), and the resulting analyses are often noisy.

The averages of total cloud cover, SST, and surface pressure are presented

here. "Cloud cover" in COADS is total cloudiness, as observed from the surface. For the regions under consideration, it correlates well with low cloud cover, i.e., marine stratocumulus, broken stratus, and trade cumulus.

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REFERENCES

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- Woodruff, S.D., R.J. Slutz, R.L. Jenne, and P.M. Steurer, A comprehensive ocean-atmosphere data set. *Bull. Amer. Meteor. Soc.*, **69**, 1239-1250.

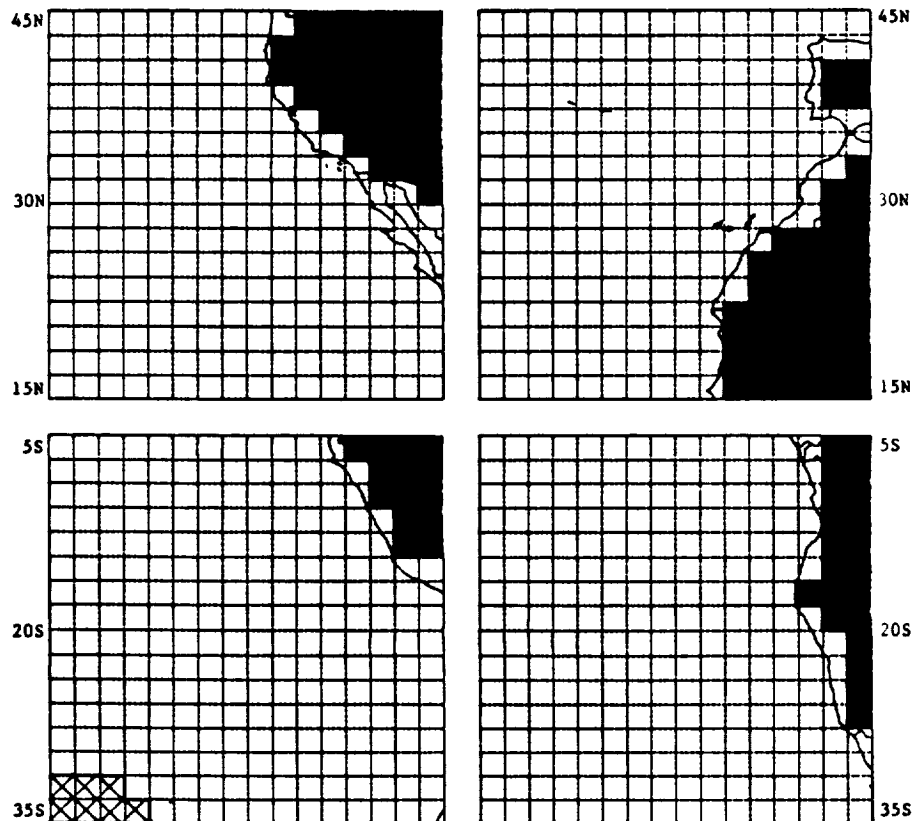
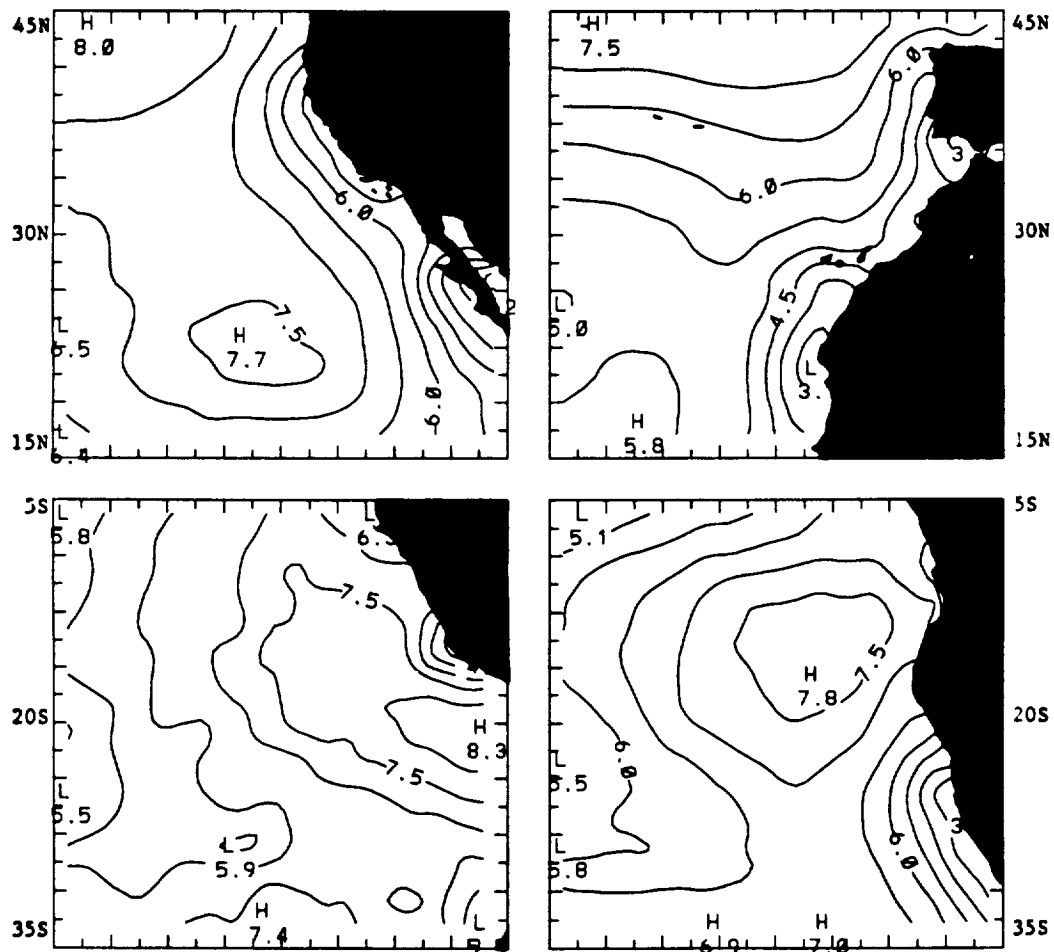


Fig. 1. Analysis domains for the four MSc regimes under consideration. Dark squares are COADS continents; 2° grid is superimposed. Hatched squares in the South Pacific were excluded from the analysis.

2. Cloudiness

The long-term average of total cloud cover (in tenths—below) is surprisingly similar to that of July (shown in Appendix B of the Grey Book [p.B-15]), with the off-shore maxima of cloudiness having somewhat lower values in the annual mean. Although very noisy, the data off Peru indicate that, both for July and for the annual mean, the maximum cloud cover occurs over the southeast

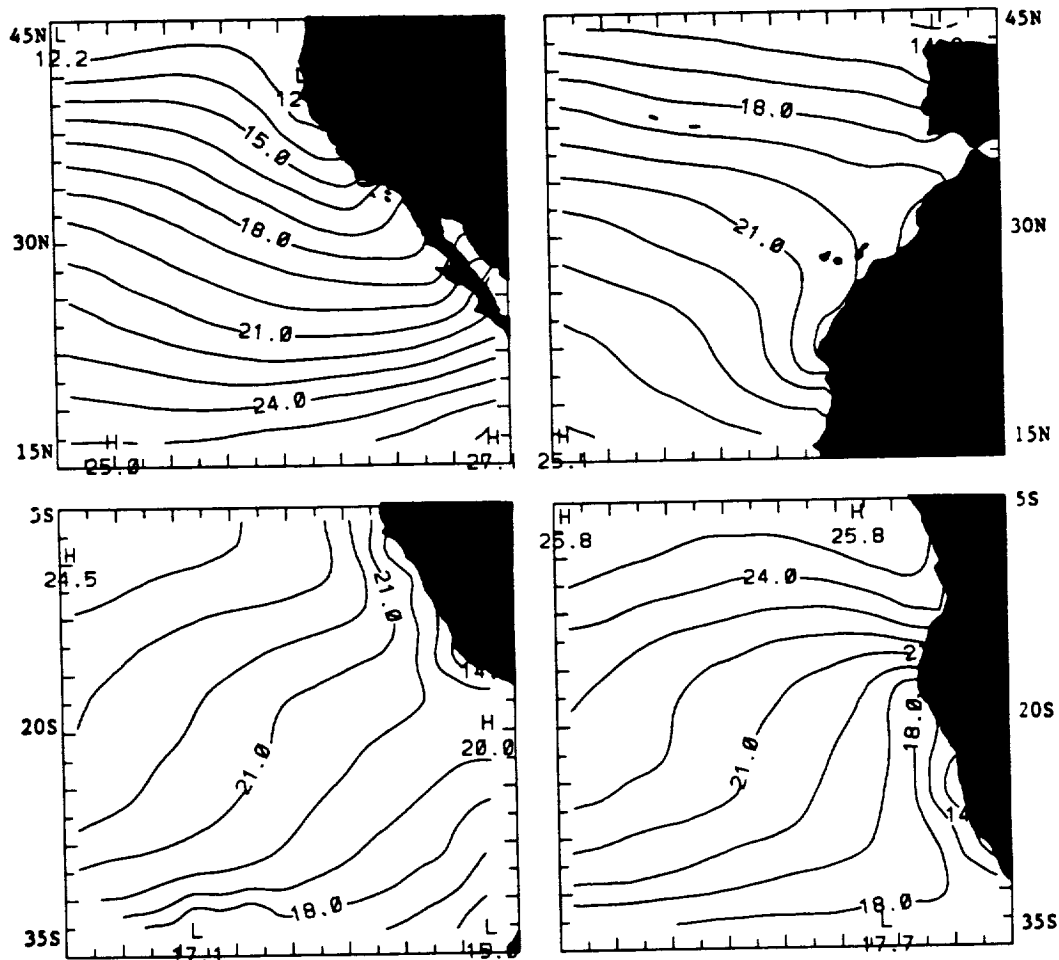
Pacific, with a large area just off shore exhibiting coverage of more than 90% in July and more than 75% in the annual average. The least cloudiness occurs off Morocco; in fact, the larger values to the north of the Morocco domain are associated with frontal activity, and the subtropical cloudiness, in the annual average, is shifted to the far southwest of the domain.



3. Sea-Surface Temperature

As with the cloud cover, the annual mean SST ($^{\circ}\text{C}$ —below) is quite similar to the July average (Appendix B [p. B-13]), although, naturally, the July temperatures are somewhat higher in the Northern Hemisphere and cooler in the Southern Hemisphere. Note that the coastal upwelling is evident in all four regimes even in the annual average, and that the bias of the temperatures off Morocco by about $+3^{\circ}\text{C}$ over the other areas holds in the annual average as well as for July. Also of interest is the much stronger N-S SST gradient off California compared to the other regimes.

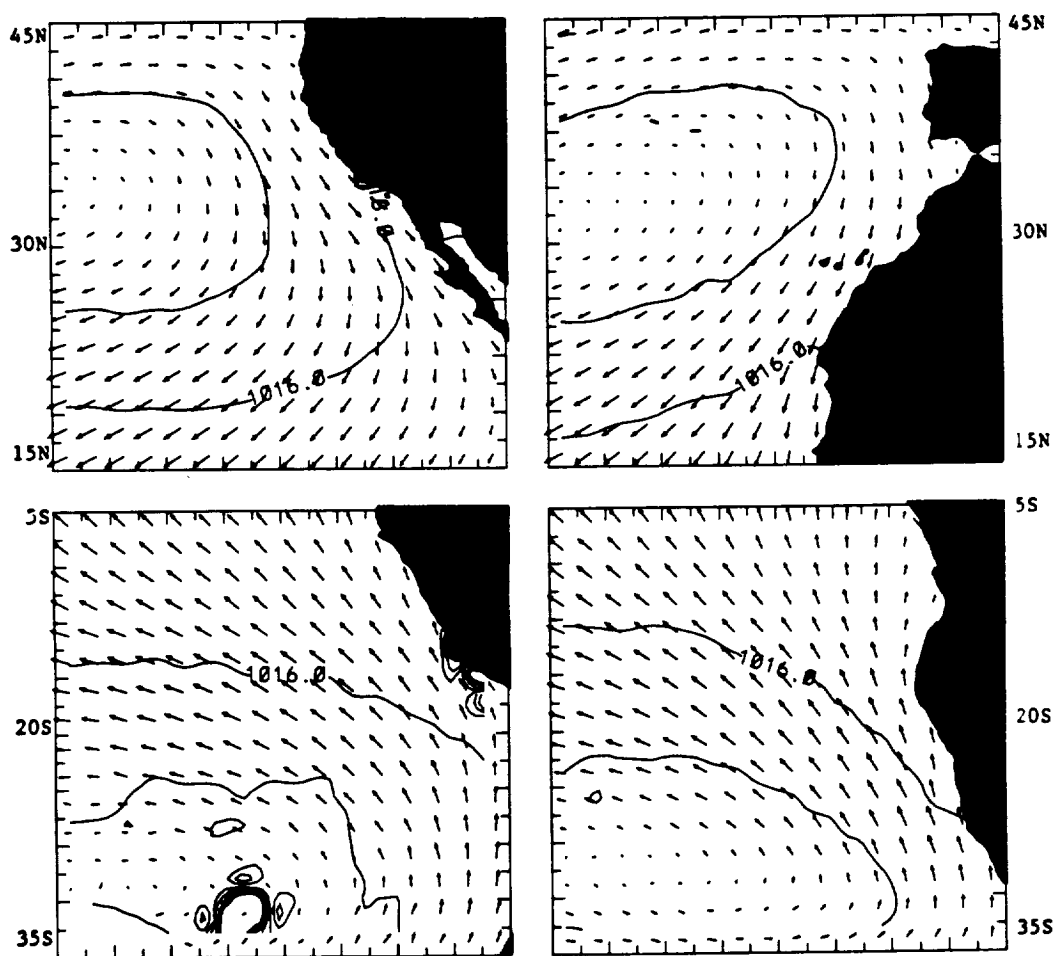
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4. Surface Pressure

The surface pressure and wind fields (below) for the annual average reflect seasonality to a greater degree than does the cloud field, but there are still large similarities between the annual average and the July average (Appendix B [p. B-14]). The subtropical highs are stronger—in both hemispheres—in July and shifted northward slightly, but the

wind fields in the areas of maximum cloud cover are remarkably similar. There is an apparent correlation of the areas of maximum cloudiness with stronger winds, suggesting that either or both advective effects and strong surface fluxes play a strong role in cloud maintenance, at least from the climatological perspective.



Surface Pressure (mb) and Winds (m/s) — Annual

0.188e+02
MAXIMUM VECTOR

